From Plato to Popper:

Platonic Forms in Modern Science and Quantum Theory

Ryan Steed

HONR 1033

Professor William Winstead

December 20, 2017

Is modern science a Platonic philosophy? Ostensibly, Plato would take issue with scientists' emphasis on empiricism, preferring purely rational inquiry. Yet there are surprising accords between Plato's epistemology and methodology and those of modern science, and Plato's ontological conclusions in *The Republic* are strikingly similar to the most recent conclusions of contemporary scientific inquiry. I will divide my comparison of Plato and scientific philosophy into three parts. First, I will examine the differences between Plato's epistemology and the epistemology of modern science by comparing Plato's conception of the Divided Line and Karl Popper's theory of critical rationalism, which I will treat as the modern scientific standard for truth. Second, I will argue that the methods used to reach knowledge in the two philosophies are extremely similar, given the epistemologies they target, and that the scientific method is an improved version of Plato's dialectic. Finally, I will argue that Plato's epistemology is in several ways prescient of the actual knowledge acquired through scientific philosophical inquiry, quantum theory. In each of these frames of analysis, I intend to demonstrate that Platonic philosophy and the philosophy of modern science are not so different after all.

Epistemology

In the realm of epistemology, modern science proposes only a slightly different standard for truth than Plato's *Republic*. Plato presents his epistemology with the metaphor of the Divided Line, in which knowledge is "a line cut into two unequal segments, one for the class that is seen, the other for the class that is intellected…"[1] The first portion of the line represents the empirical; the second portion is the rational. The rational is composed of *ideas*, standards which natural

[1] Plato, *The Republic of Plato*, trans. Allan Bloom (New York: Basic Books, 1968), 509d(7-8).

objects embody to some extent. One who has intellected the *idea* of beauty, for instance, "believes that there is something fair itself and is able to catch sight both of it [the *idea* of beauty] and of what participates in it [beautiful objects], and doesn't believe that what participates in it is it itself, nor that it itself is what participates…"[2] For Plato, *ideas* are the only form of true knowledge because they are the only elements which have constant being. Objects are ever in the process of becoming, approaching several different absolute forms at once but never fully embodying a single one.

How does Plato's Divided Line relate to modern science? First, the actual epistemology of modern philosophers of science heavily invokes Platonic rationalism. Karl Popper defined a scientific epistemology that recognizes the futility of observing the shadows on the walls of Plato's Cave, adding that "we do possess criteria which, *if we are lucky*, may allow us to recognize error and falsity… And, when they are recognized, our own errors provide the dim red lights which help us in groping our way out of the darkness of our cave."[3] Popper's critical rationalism extends Platonic *ideas* without violating the premise that the basis of sensible knowledge is unreliable and that there are no criteria for determining truth, instead arguing that the conclusions of rational thought may be evaluated and potentially dismissed. Modern science performs this evaluation with empirical testing, under the assumption that the forms are consistently, if not accurately, reflected in the observable world. I would not expect Plato to refute this assumption. After all, the discursive aim of *The Republic* is to establish an *idea* of justice and goodness and apply those *ideas* to evaluating actions in society; it is therefore safe to say that knowledge of the forms grants the ability to recognize the forms in those objects that

---

[2] Ibid., 476(c10-d4).

[3] Karl Popper, *Conjectures and Refutations: The Growth of Scientific Knowledge* (New York: Harper and Row, 1968), 28.

still in a state of becoming. Thus scientific rationalism, as Popper defines it, presents an epistemology that is merely an extension of Plato's; the criteria for truth are obscure and true knowledge is necessarily rational, but rational knowledge is still subject to criticism, often empirical. Truth must not only be justifiable and falsifiable, but have a proof that is possible to critique rationally. By imposing these conditions, the modern scientific method provides a universal methodology for verifying the truth of mathematical laws, or *ideas*.

Second, actual expressions of rational thought, such as mathematics, fall on the authentic side of the Divided Line by Plato's own admission. However, Plato criticizes geometer's tendencies to rely on unfounded hypotheses, further partitioning the intelligible into "thought" (the scientist's knowledge) and "intellect" (the philosopher's):

> [Men who work in geometry] make the arguments for the sake of the square itself and the diagonal itself, not for the sake of the diagonal they draw, and likewise with the rest. These things themselves that they mold and draw, of which there are shadows and images in water, they now use as images seeking to see those things themselves…[4]

In short, mathematicians accept basic premises but do not seek to explain the origins or nature of those premises or derive them from sensible things. Worse, mathematicians never relate their conclusions to a single, unifying principle. For Plato, this principle is the *idea* of the good, the light of truth and the foundation of Platonic morality and ethics: "… you have many times heard that the *idea* of the good is the greatest study and that it's by availing oneself of it along with just things and the rest that they become useful and beneficial."[5] Benson defends modern mathematicians by arguing that Plato does not take explicit exception to the use of empirical

---

[4] Plato, *The Republic*, 510d(7-11).
[5] Ibid., 505a(2-5).

hypothesis or the use of diagrams; instead, he protests mathematicians who do not carry their forms to such a unifying principle, preferring that they extend their methods to the dialectic, Plato's favored method of ontological inquiry:[6]

> The mathematical disciplines employed correctly compose ten years of the philosopher-rulers' education. So practiced they do not misuse sensible objects and they hand over their results to a higher discipline, all the way up to the Form of the Good, the unhypothetical *archê*.[7]

Thus Plato's criticism is inherently methodological and must be addressed in the next section; as far as epistemology is concerned, mathematics is a valuable representation of reality. It may be argued that the link between scientific principles and moralistic applications has not been fully established in modernity, and in this sense, scientific practice falls short of Plato's expectations. Nonetheless, it is evident that the standard for truth in scientific epistemology belongs to the intelligible and perhaps even in the realm of the forms.

Methodology

Plato's attack on mathematicians is more a criticism of methodology than of epistemology. The axioms of geometers consign their investigation to the sensible, which "does not go to a beginning because it is unable to step out above the hypotheses."[8] Plato, the dialectician, advocates a purely rational, discursive form of inquiry typified in the dialogues of *The Republic*, which guide the philosopher to the *ideas* without empirical aid. Aristotle, Plato's

---

[6] Hugh Benson, "The Problem Is Not Mathematics, But Mathematicians: Plato and the Mathematicians Again," *Philosophia Mathematica* 20, no. 2 (2012): 170-199.

[7] Benson, "The Problem Is Not Mathematics, But Mathematicians."

[8] Plato, *The Republic*, 511a3.

pupil, expands on his teacher's dialectic to build such a method of first-principles reasoning, and is credited for the philosophical basis of scientific methodology today:

> The natural course is to proceed from what is clearer and more knowable to us, to what is more knowable and clear by nature; for the two are not the same… The things which are in the first instance clear and plain to us are rather those which are compounded. It is only later, through an analysis of these, that we come to know elements and principles.[9]

Hypothesis testing proceeds from this sort of "first-principles" empiricism which reduces the body of sensible knowledge to single points of reference. From these hypotheses, the philosopher may build a rational argument that is eventually elevated above its empirical roots and made entirely self-consistent among the forms. Plato addresses hypotheses himself:

> … by the other segment of the intelligible I mean that which argument itself grasps with the power of dialectic, making the hypotheses not beginnings but really hypotheses – that is, steppingstones and springboards – in order to reach what is free from hypothesis at the beginning of the whole… making no use of anything sensed in any way, but using forms themselves, going through forms to forms, it ends in forms too.[10]

The forms (and knowledge) are entirely self-contained and self-sustaining. According to Plato, the empirical may serve as a stepping stone, but is not strictly necessary for rational conclusion. In summary, "if geometry compels one to look at being; it is suitable; if at becoming, it is not suitable."[11] Further, "the dialectical way of inquiry proceeds in this direction, destroying the hypotheses, to the beginning itself in order to make it secure…"[12] Plato requires that empirical

---

[9] Aristotle, *Physics*, trans. William Charlton (Oxford: Clarendon Press, 1970), 184a(17-23).

[10] Plato, *The Republic*, 511(b3-c1).

[11] Ibid., 526e6.

[12] Ibid., 533c(7-9).

hypotheses elevate the soul to self-sustaining rational discourse (at which point the original hypotheses are rendered useless) to be considered a valid method of investigation. In an interesting corollary to Popper's rational criteria, Byrd argues that hypotheses which are not first principles must necessarily produce contradictions, and when these contradictions are recognized a new hypothesis is formed. "So, one can only move to higher hypothesis by first putting forth the lower, much as one must ascend a staircase step by step."[13] The process of contradiction and revision continues until a first principle, which raises no contradictions, is reached, and from that first principle new *ideas* are derived. Those *ideas* are confirmed in the empirical world by critical analysis. The four steps of this cycle – contradiction, revision, derivation, and criticism – are the most notable elements of the scientific process that are truly exogenous to Plato's original methodology.

In fact, though the down-up reasoning of hypothesis testing, which carries the philosopher from the empirical to a rational conclusion, is decidedly Platonic, the practice of scientific criticism does not agree so easily with Plato's dialectic. Aristotle values mathematical law above dialectical conclusion, stating that dialectical questions "appear to be correct to everyone or the majority or the wise," implying that dialectical knowledge is based on human popularity and is not universal.[14] Solmsen elucidates:

> [Dialectic] deals, as Aristotle repeatedly points out, with probabilities (*endoxa*), whereas mathematical demonstrations have the quality of necessity (*anagkaion*)… Dialectic in his view lacks a cogent method that could guarantee the validity of its conclusions…

---

[13] Miriam Byrd, "Dialectic and Plato's Method of Hypothesis," *Apeiron* 40, no. 2 (2007), 156.

[14] Aristotle, *Topics*, trans. Paul Slomkowski (Leiden: Brill, 1997), 100b21-23.

> [Dialectic], to arrive at true results, must be practiced with a sure sense for the essential, a special touch which Plato trusted he had and which he tried to pass on to others.[15]

Solmsen's interpretation implies that dialectical conclusions are not only evaluated by popular appeal, but also subjectively – there is some inherent quality that enables a philosopher to distinguish dialectical truth from dialectical falsehood. Popper and all the other scientists after Aristotle wrangle with the very same problem: to establish criteria with which to evaluate the dialectic requires either a subjective or popular approach, neither of which is universal and reliable. In this larger sense, philosophers of science are very Platonic, seeking a universal standard of truth with which to evaluate dialectical claims. Yet in the literal sense of *The Republic*, it is with empirical testing – coincidentally the most visible and popularized stage of the scientific process – that modernity breaks from Plato's methodology.

Ontological Conclusions

Given the distinct similarities between the methodologies of Plato and the philosophy of science and setting aside the moral imperative that science lacks, I will now attempt to compare the ontological results of each philosophical inquiry. Some of the most compelling results of the scientific method have emerged only recently in the field of quantum mechanics, spurring a flurry of philosophical interpretation. In this section, I argue that the two most popular interpretations of quantum theory are similar to Plato's ontology in three ways: first, that quantum mechanics is capable of producing a statistical version of very fundamental *ideas* of nature and that the observation of quantum effects eerily echoes Plato's conception of the sensible side of the Divided Line; second, that quantum mechanics is unlike regular empiricism

---

[15] Friedrich Solmsen, "Platonic Values in Aristotle's Science," *Journal of the History of Ideas* 39, no. 1 (1978), 5.

in that it supposes the inconstancy of observation; and third, that quantum mechanics is rationally self-consistent, just like rational conclusions using the forms.

One of the most fundamental discoveries of quantum physics is Schrödinger's wave function, an equation that describes matter and physical systems as a time-dependent wave, or distribution of probabilities. Subscribers to the Copenhagen interpretation of quantum mechanics believe that Schrödinger's wave equation predicts with a certain probability the likelihood of a certain measurement on a physical system, or "state vector."[16] The probability distribution for the energy, momentum, position, or any other quality of matter is based on a superposition of many matter waves at a particular point. Because the act of measurement necessarily introduces new waves to that point and interferes with the original quantum system, the range of probabilities provided by the wave function are conditional upon the act of measurement by a *single* observer or entanglement. Everett took exception to this simplifying assumption, arguing that quantum mechanics must allow for *multiple* observers. Unwilling to assume that measurement is a non-quantum act (necessitating the presence of two realms of physical laws, the classical and the quantum), Everett instead regarded the wave function as a complete model for the physical world, hypothesizing a *universal* wave function that describes the state of the entire universe of matter. This truth may even be described by a single *idea*, though perhaps not Plato's moralistic good. As Everett puts it:

> Since the universal validity of the state function is asserted, one can regard the state functions themselves as the fundamental entities, and one can even consider the state function of the whole universe. In this sense this theory can be called the theory of the

[16] Stefano Osnaghi, "Van Fraassen, Everett, and the Critique of the Copenhagen View of Measurement," *Principia* 12, no. 2 (2008): 155-176.

"universal wave function," since all physics is presumed to follow from this function alone.[17]

The more recent principle of decoherence suggests that individual or universal wave functions must "collapse" when met with outside interference, reducing the state vector from a quantum superposition or probability distribution to a single outcome.[18] Such a wave function in many ways reflects the central premise of Plato's Divided Line, especially the notion that the split between *ideas* and objects is that of some decay from perfect truth. The ontology of the Divided Line and the Everettian interpretation of quantum mechanics (coupled with decoherence theory) agree that our universe accords with some absolute, God's eye truth that must necessarily collapse to some subjective, imperfect perception when sensed by an observer in the physical world.[19]

Further, quantum mechanics is uniquely Platonic *because* it does not suppose the constant accuracy of observation. Unlike the geometer who bases her rational conclusions in reflected objects, or the poet who argues with rhetoric not her own, the modern physicist approaches observation with the knowledge that what she senses is merely a combination of the many superimposed waves. In Plato's framework, what she senses is merely a combination of many forms that the object in question is *becoming* but none which it truly *is*. In fact, the very nature of quantum observation entirely avoids Plato's warning that empiricism does not "summon the intellect… because they seem to be adequately judged by sense" by undermining empirical

---

[17] Hugh Everett, "The Theory of the Universal Wave Function," in *The Many Worlds Interpretation of Quantum Mechanics*, ed. Bryce Dewitt and Neill Graham (Princeton: Princeton University Press, 1973), 9.

[18] Scott Tanona, "Decoherence and the Copenhagen Cut," *Synthese* 190, no. 16 (2013): 3625-3649.

[19] Carlo Rovelli, "Relational Quantum Mechanics," *International Journal of Theoretical Physics* 35, no. 8 (1996): 1637-1678.

observation itself.[20] Quantum theory declares that no wave state may be adequately judged by sense, only by mathematics or some other intelligible, abstract idea.

Lastly, like the forms, quantum theory may be totally self-consistent. Grinbaum describes how scientists are currently attempting to reconstruct modern quantum theory from first-principles, a few simple axioms from which the entirety of the scientific *ideas* may be derived.[21] Empirical data is used to reach these axioms, but from these axioms fundamental laws of nature are derived. Most importantly, these axioms may be used to relationally prove their own existence, meeting Plato's requirement for dialectic hypothesis. In a larger sense, scientific philosophy has accomplished a truly Platonic shift: the transition from classical physics, a mere shadow on the wall mimicking the inner workings of the universe, to quantum mechanics, a step closer to the objects behind the prisoners or the sun outside. As Socrates speculates, "Whether it is really so or not cannot be properly insisted on. But that there is some such thing to see must be insisted on."[22] Quantum mechanics is merely the next hypothesis science plants her foot on, waiting for the contradictions that crumble the ledge and force her to reach for the next ledge.

Though there are strong epistemological similarities between Aristotle and his scientific descendants and Plato's *Republic*, philosophers of science have altered and expanded Plato's dialectic into modern scientific inquiry. The astounding similarities between Plato's ontology and quantum theorists' most recent deductions are further proof of the prescience and insight of Plato's philosophy. Most importantly, the concepts set forth in Plato's *Republic*, from epistemology to methodology, are undoubtedly reflected in modern scientific philosophy and

---

[20] Plato, 523b9.

[21] Alexei Grinbaum, "Reconstruction of Quantum Theory," *The British Journal for the Philosophy of Science* 58, no. 3 (2007): 387-408.

[22] Plato, *The Republic*, 533a(1-5).

therefore in even the most modern discoveries. In many ways, we have Plato to thank for the state of knowledge today.

Bibliography

Aristotle. *Physics*. Translated by William Charlton. Oxford: Clarendon Press, 1970.

Aristotle. *Topics*. Translated by Paul Slomkowski. Leiden: Brill, 1997.

Benson, Hugh. "The Problem Is Not Mathematics, But Mathematicians: Plato and the Mathematicians Again." *Philosophia Mathematica* 20, no. 2 (2012): 170-199.

Byrd, Miriam. "Dialectic and Plato's Method of Hypothesis." *Apeiron* 40, no. 2 (2007): 141-158.

Everett, Hugh. "The Theory of the Universal Wave Function." In *The Many Worlds Interpretation of Quantum Mechanics*, edited by Bryce Dewitt and Neill Graham, 3-140. Princeton: Princeton University Press, 1973.

Grinbaum, Alexei. "Reconstruction of Quantum Theory." *The British Journal for the Philosophy of Science* 58, no. 3 (2007): 387-408.

Osnaghi, Stefano. "Van Fraassen, Everett, and the Critique of the Copenhagen View of Measurement." *Principia* 12, no. 2 (2008): 155-176.

Plato. *The Republic of Plato*. Translated by Allan Bloom. New York: Basic Books, 1968.

Popper, Karl. *Conjectures and Refutations: The Growth of Scientific Knowledge*. New York: Harper and Row, 1968.

Rovelli, Carlo. "Relational Quantum Mechanics." *International Journal of Theoretical Physics* 35, no. 8 (1996): 1637-1678.

Solmsen, Friedrich. "Platonic Values in Aristotle's Science." *Journal of the History of Ideas* 39, no. 1 (1978): 3-23.

Tanona, Scott. "Decoherence and the Copenhagen Cut." *Synthese* 190, no. 16 (2013): 3625-3649.